CETA 82-4

Hand-Held Calculator Algorithms for Coastal Engineering (Second Series)

by

Todd L. Walton, Jr.

COASTAL ENGINEERING TECHNICAL AID NO. 82-4

NOVEMBER 1982

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COASTAL ENGINEERING
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CETA 82-4	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) HAND-HELD CALCULATOR ALGORITHMS FOR COASTAL ENGINEERING (Second Series)		5. TYPE OF REPORT & PERIOD COVERED Coastal Engineering Technical Aid 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Todd L. Walton, Jr.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of the Army Coastal Engineering Research Center (CEREN-EV) Kingman Building, Fort Belvoir, Virginia 22060		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS C31181
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Army Coastal Engineering Research Center Kingman Building, Fort Belvoir, Virginia 22060		12. REPORT DATE November 1982 13. NUMBER OF PAGES 41
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Calculator algorithms
Coastal engineering
Wave generation
Wave transformations

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included for use with HP41CV hand-held calculators which employ the Reverse Polish Notation (RPN). These programs can be used to compute linear wave parameters, orbital velocities, breaking wave height and direction, shallow-water wave forecasts, depth-limited breaking wave height, and wave transmission past a vertical barrier.

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PREFACE

This report provides coastal engineers a second series of algorithms for a number of hand-held calculator programs for coastal engineering, primarily in the area of wave transformations and wave generation. These algorithms were developed under the U.S. Army Coastal Engineering Research Center's (CERC) Littoral Data Collection Methods and Their Engineering Application work unit, Shore Protection and Restoration Program, Coastal Engineering Area of Civil Works Research and Development.

The report was prepared by Dr. Todd L. Walton, Jr., Hydraulic Engineer, under the general supervision of Dr. J.R. Weggel, Chief, Evaluation Branch, and Mr. N. Parker, Chief, Engineering Development Division.

The author acknowledges the assistance of J. Dean in preparing the manuscript. The review by Dr. J.R. Weggel is appreciated.

Technical Director of CERC was Dr. Robert W. Whalin, P.E., upon publication of this report.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

Ted E Bishop

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: C = (5/9) (F -32).
To obtain Kelvin (K) readings, use formula: K = (5/9) (F -32) + 273.15.

HAND-HELD CALCULATOR ALGORITHMS FOR COASTAL ENGINEERING (Second Series)

by
Todd L. Walton, Jr.

I. INTRODUCTION

The advent of the hand-held programable calculator has led to the development of numerous programs in various fields of engineering and science. Coastal engineering is no exception. This report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation.

There are basically two types of hand-held programable calculators: those that use algebraic logic, such as Texas Instruments, Algebraic Operating System (AOS) notation, and those that use Reverse Polish Notation (RPN), such as Hewlett-Packard. The six programs presented herein are versions of RPN logic suitable for use on HP41CV programable calculators with or without accessory printer. Each program is documented, the assumptions are briefly described, and references to more detailed presentations of the theory are given. This same set of algorithms was programed for the TI-59 (AOS logic) and HP67 (RPN logic) calculators in an earlier report with the same title (Walton, Birkemeier, and Weggel, 1982)[1].

Each of the RPN programs incorporates HP41 compatible print routines which print and label all input and output parameters. The user only has to enter the input parameters and the results are automatically computed and printed. Since the printing routines increase program length by as much as 25 percent, use of a magnetic card for permanent program storage is recommended. All print steps are marked with asterisks and need not be entered if printing is not desired.

II. PROGRAMS

Six programs (100, 101, 102, 103, 104, and 105) are presented in this report. Program 100, a simple program that computes linear wave theory wavelength for a given depth, is designed to be used as the basis for any program that requires wavelength; in fact, it has been incorporated into programs 101, 102, and 105.

Program 101 is another basic program which computes not only wavelength but also a number of other linear wave theory parameters. This program forms the basis for program 102 and can be adapted to other programs as well.

[1]WALTON, T.L., BIRKEMEIER, W.A., and WEGGEL, J.R., "Hand-Held Calculator Algorithms for Coastal Engineering," CETA 82-1, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Jan. 1982.

Program 102 computes linear wave parameters and breaking wave height and direction based on nearshore or deepwater wave information. Program 103 can be used to forecast wave height and period in shallow water. Program 104 and 105 address wave conditions at structures--program 104 predicts the depth-limited design breaking wave height at a structure; 105 uses Fuchs' equation to predict wave transmission over a thin barrier.

Each program allows either English or metric input and output. Program listings are annotated, making it possible to follow the logic of the algorithm and to make modifications if desired.

There are undoubtedly many calculator programs not included here that have been developed on coastal engineering subjects. Practicing engineers who would like to disseminate such programs (in either AOS or RPN) to other users are encouraged to submit them to the Coastal Engineering Research Center (CERC). If the response is great enough, additional reports presenting the programs will be prepared. Comments, programs, or suggestions for programs should be sent to:

Commander and Director
US Army Coastal Engineering Research Center
ATTN: Evaluation Branch
Kingman Building
Fort Belvoir, VA 22060

These programs and future programs will generally correspond to the following numbering scheme:

Miscellaneous	0-99
Waves and currents	100-299
Inlets	300-499
Beaches	500-699
Geology	700-899
Structures	900-1099

In general, the documentation of programs submitted should be in a format paralleling that of the programs presented in this report. A blank set of forms which can be reproduced is included in the Appendix.

Program Description

Program Title	100R-41CV Linear Wave Theory Wavelength (RPN Logic)
Name	T.L. Walton, Jr. — Date 1/82
Address	Coastal Engineering Research Center
City	Kingman Building Fort Belvoir, — State Virginia — Zip Code 22060

Program Description, Equations, Variables, etc.

This algorithm takes deepwater wavelength as input and using the depth at a given site iterates to obtain wavelength by linear wave theory. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Eq. (2-4), Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

100R-41CV-1

User Instructions

100R-41CV LINEAR THEORY WAVELENGTH (RPN LOGIC)

SIZE: 011

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	LOAD PROGRAM (WAVEL)		[XEQ] "WAVEL"	E OR M?
	TO CALCULATE L IN ENGLISH	UNITS:		
2	PRESS GTO "E"		GTO "E"	
3	PRESS R/S		[R/S]	PERIOD?
4	ENTER PERIOD T, PRESS R/S	T(sec)	[R/S]	DEPTH?
5	ENTER DEPTH D, PRESS R/S	d (ft)	[R/S]	L (ft)
	TO CALCULATE L IN METRIC	UNITS:		
2a	PRESS GTO "M"		GTO "M"	
3a	PRESS R/S		[R/S]	PERIOD?
4a	ENTER PERIOD T, PRESS R/S	T(sec)	[R/S]	DEPTH?
5a	ENTER DEPTH D, PRESS R/S	d(meters)	[R/S]	L(meters)
	Example 1 and 1a			
	T= 10sec , d= 10ft (3.05m)			
	ENGLISH AND METRIC PRINTOUTS			

```
ENGLISH
PERIOD=
          10.0000   ***
DEPTH=
          10.0000   ***
LENGTH=
         175.7738   ***


METRIC
PERIOD=
          10.0000   ***
DEPTH=
           3.0500   ***
LENGTH=
          53.6063   ***
```

note: " = [ALPHA]

100R-41CV-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
01	♦LBL "WAVEL"		
02	"E OR M ?"		
03	PROMPT		
04	♦LBL E		
05	32.2		
06	STO 06		g(English) $\rightarrow R_{06}$
* 07	"ENGLISH"		
* 08	PRA		
09	GTO 01		
10	♦LBL "M"		
* 11	"METRIC"		
* 12	PRA		
13	9.81		
14	STO 06		g(metric) $\rightarrow R_{06}$
15	♦LBL 01		
* 16	"PERIOD="		
* 17	PRA		
18	"PERIOD?"		
19	PROMPT		
* 20	PRX		
21	STO 07		$T \rightarrow R_{07}$
22	X↑2		
23	RCL 06		
24	*		
25	2		
26	/		
27	PI		
28	/		
29	STO 01		$L_0 \rightarrow R_{01}$
* 30	"DEPTH="		
* 31	PRA		
32	"DEPTH?"		
33	PROMPT		
* 34	PRX		
35	ENTER↑		
36	2		
37	*		
38	PI		
39	*		
40	STO 05		$2\pi d \rightarrow R_{05}$
41	RCL 01		
42	♦LBL "ITERAT"		
43	STO 03		$L_{old} \rightarrow R_{03}$
44	1/X		
45	RCL 05		
46	*		
47	STO 04		
48	E↑X		
49	RCL 04		
50	CHS		
51	E↑X		
52	-		
53	RCL 04		
54	E↑X		
55	RCL 04		
56	CHS		
57	E↑X		
58	+		
59	/		$\tanh \frac{2\pi d}{L_{old}}$
60	RCL 01		
61	*		$L' = L_0 \tanh\left(\frac{2\pi d}{L_{old}}\right)$
62	RCL 03		
63	+		
64	2		
65	/		
66	STO 02		$\frac{L' + L_{old}}{2} \rightarrow R_2$
67	RCL 03		
68	-		
69	ABS		
70	1		ϵ (error tolerance) 1ft or 1 meter
71	X>Y?		
72	GTO 05		
73	RCL 02		
74	GTO "ITERAT"		
75	♦LBL 05		
76	RCL 02		L in display
* 77	"LENGTH="		
* 78	PRA		
* 79	PRX		
80	STOP		
81	.END.		

100R-41CV-3

* THESE STEPS MUST BE DELETED IF NO PRINTER IS AVAILABLE

Program Description

Program Title	101R-41CV Calculation of Wave Parameters from Linear Theory (RPN Logic)		
Name	T.L. Walton, Jr.		1/82
Address	Coastal Engineering Research Center Kingman Building		
City	Fort Belvoir,	State Virginia	Zip Code 22060

Program Description, Equations, Variables, etc.

This program calculates the product of the wave number and depth, kd, the ratio of group wave speed to wave celerity, $n = 0.5\ (1+2kd/\sinh 2kd)$, the group wave speed, C_g, the shoaling coefficient, K_s, the refraction coefficient, K_r, horizontal orbital velocity, u, and vertical orbital velocity, w.

Program input includes wave period, T, deepwater wave angle, α_o, deepwater wave height, H_o, wave phase angle, θ, depth of water, d, at which results are desired, and depth from surface, z, at which velocities are calculated. This program assumes straight and parallel offshore bottom contours for assumption of Snell's law of refraction. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

If printer is not used, R/S must be inserted where output values are desired (i.e., where printer output steps are deleted).

User Instructions

101R-41CV CALCULATION OF WAVE PARAMETERS FROM LINEAR THEORY (RPN LOGIC) SIZE: 021

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	LOAD PROGRAM (LINEAR)		[XEQ] "LINEAR"	E OR M?
	TO COMPUTE IN ENGLISH UNITS:			
2	PRESS GTO "E"		GTO "E"	
3	PRESS R/S		[R/S]	PERIOD?
4	ENTER PERIOD T, PRESS R/S	T(sec)	[R/S]	DEPTH?
5	ENTER DEPTH D, PRESS R/S	d (ft.)	[R/S]	AO?
6	ENTER WAVE ANGLE α_0,			
	PRESS R/S	α_0(deg)	[R/S]	HO?
7	ENTER WAVE HEIGHT H_0, PRESS R/S.	H_0(ft.)	[R/S]	Z?
8	ENTER DEPTH BELOW SURFACE, Z,			
	PRESS R/S	Z (ft.)	[R/S]	PHASE?
9	ENTER WAVE PHASE ANGLE Θ,			
	PRESS R/S.	Θ(deg).	[R/S]	
10	READ kd (wave number × depth)			kd
11	READ n (ratio of group wave speed to wave celerity)			n
12	READ Cg (group wave speed)			Cg (ft/sec)
13	READ Ks (shoaling coefficent)			Ks
14	READ Kr (refraction coefficent)			Kr
15	READ H (wave height)			H (ft.)
16	READ u (horizontal orbital velocity)			u (ft/sec)
17	READ W (vertical orbital velocity)			w (ft/sec)
	note: " = [ALPHA]			

101R-41CV-2

User Instructions

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
	TO COMPUTE IN METRIC UNITS:			
2a	PRESS GTO "M"		GTO "M"	
	STEPS 3a - 17a ARE THE SAME AS STEPS 3-17 EXCEPT			
	IMPUT H_0, Z in METERS			
	OUTPUT H (meters)			
	C_g, u, w IN METERS/SEC			
	EXAMPLES 1 and 1a:			
	$T = 8$ sec, $d = 50$ ft (15.244 m), $\alpha_0 = 30°$			
	$H_0 = 18$ ft (5.4878 m), $z = -15$ ft (-4.5732 m), $\theta = 60°$			
	PRINTOUTS:			

```
ENGLISH
PERIOD=
         8.0000   ***
DEPTH=
        50.0000   ***
AO=
        30.0000   ***
HO=
        18.0000   ***
Z=
       -15.0000   ***
PHASE=
        60.0000   ***
KD=
         1.1631   ***
N=
         0.7294   ***
CG=
        24.6248   ***
KS=
         0.9124   ***
KR=
         0.9746   ***
H=
        16.0099   ***
U=
         2.9437   ***
W=
         3.4256   ***
```

```
METRIC
PERIOD=
         8.0000   ***
DEPTH=
        15.2440   ***
AO=
        30.0000   ***
HO=
         5.4878   ***
Z=
        -4.5732   ***
PHASE=
        60.0000   ***
KD=
         1.1600   ***
N=
         0.7302   ***
CG=
         7.5367   ***
KS=
         0.9103   ***
KR=
         0.9752   ***
H=
         4.8716   ***
U=
         0.9008   ***
W=
         1.0465   ***
```

101R-41CV-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
01	♦LBL "LINEAR"		
02	"E OR M ?"		
03	PROMPT		
04	♦LBL E		
05	32.2		
06	STO 14		g(English) → R_{14}
*07	"ENGLISH"		
*08	PRA		
09	GTO 03		
10	♦LBL "M"		
*11	"METRIC"		
*12	PRA		
13	9.81		
14	STO 14		g(Metric) → R_{14}
15	♦LBL 03		
16	"PERIOD?"		
17	PROMPT		
*18	"PERIOD="		
*19	PRA		
*20	PRX		
21	STO 02		$T \rightarrow R_{02}$
22	"DEPTH?"		
23	PROMPT		
*24	"DEPTH="		
*25	PRA		
*26	PRX		
27	PI		
28	*		
29	2		
30	*		
31	STO 01		$2\pi d \rightarrow R_{01}$
32	"A0?"		
33	PROMPT		
*34	"A0="		
*35	PRA		
*36	PRX		
37	SIN		
38	STO 00		$\sin\alpha_0 \rightarrow R_{00}$
39	"H0?"		
40	PROMPT		
*41	"H0="		
*42	PRA		
*43	PRX		
44	STO 08		$H_0 \rightarrow R_{08}$
45	"Z?"		
46	PROMPT		
*47	"Z="		
*48	PRA		
*49	PRX		
50	STO 12		$z \rightarrow R_{12}$
51	"PHASE?"		
52	PROMPT		
*53	"PHASE="		
*54	PRA		
*55	PRX		
56	STO 15		$\theta \rightarrow R_{15}$
57	♦LBL "MAIN"		
58	XEQ 00		
59	2		
60	*		
61	STO 11		$4\pi d/L \rightarrow R_{11}$
62	XEQ 01		
63	1/X		
64	RCL 11		
65	*		
66	1		
67	+		
68	2		
69	/		
*70	"N="		$n \rightarrow R_x$
*71	PRA		
*72	PRX		
73	STO 11		$n \rightarrow R_{11}$
74	RCL 04		
75	*		
76	RCL 02		
77	/		
*78	"CG="		$C_g \rightarrow R_x$
*79	PRA		
*80	PRX		
81	1/X		
82	RCL 02		
83	*		
84	RCL 14		
85	*		
86	4		
87	/		
88	PI		
89	/		
90	SQRT		$K_s = \sqrt{C_{g0}/C_g} \rightarrow R_x$
*91	"KS="		
*92	PRA		
*93	PRX		
94	STO 11		$K_s \rightarrow R_{11}$
95	RCL 00		
96	RCL 01		
97	*		
98	RCL 03		
99	/		$K_0 d \sin\alpha_0$
100	RCL 09		
101	/		$\sin\alpha$
102	X↑2		
103	1		
104	-		
105	CHS		$\cos^2\alpha$
106	1/X		
107	1		
108	ENTER↑		
109	RCL 00		
110	X↑2		
111	-		

*DELETE THESE LINES IF A PRINTER IS NOT AVAILABLE.
ALSO SEE 'OPERATING LIMITS AND WARNINGS' ON PAGE 101R-41CV-1.

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
112	*		
113	SQRT		
114	SQRT		
115	STO 10		$K_r \to R_{10}$
*116	"KR="		
*117	PRA		$K_r \to R_x$
*118	PRX		
119	RCL 08		
120	RCL 10		
121	*		
122	RCL 11		
123	*		
*124	"H="		$H \to R_x$
*125	PRA		
*126	PRX		
127	RCL 14		
128	*		
129	RCL 02		
130	*		
131	2		
132	/		
133	RCL 04		
134	/		
135	RCL 06		
136	/		
137	STO 08		$\frac{H}{2}\frac{gT}{L}\frac{1}{\cosh\left(\frac{2\pi d}{L}\right)} \to R_{08}$
138	RCL 01		
139	2		
140	/		
141	PI		
142	/		
143	RCL 12		
144	+		
145	2		
146	*		
147	PI		
148	*		
149	RCL 04		
150	/		
151	STO 05		$\frac{2\pi(z+d)}{L} \to R_{05}$
152	XEQ 02		
153	RCL 08		
154	*		
155	RCL 15		
156	COS		
157	*		
*158	"U="		$u \to R_x$
*159	PRA		
*160	PRX		
161	RCL 05		
162	XEQ 01		
163	RCL 03		
164	*		
165	RCL 15		
166	SIN		
167	*		

STEP	KEY ENTRY	KEY CODE	COMMENTS
*168	"W="		$\omega \to R_x$
*169	PRA		
*170	PRX		
171	RTN		
172	♦LBL 00		"kd" subroutine; lines 172-218
173	RCL 02		
174	X↑2		
175	RCL 14		
176	*		
177	2		
178	/		
179	PI		
180	/		
181	STO 03		$L_o \to R_{03}$
182	♦LBL "ITERAT"		
183	STO 11		$L_{old} \to R_{11}$
184	1/X		
185	RCL 01		
186	*		
187	STO 13		$\frac{2\pi d}{L_{old}} \to R_{13}$
188	XEQ 02		
189	STO 06		$\cosh(R_{13}) \to R_{06}$
190	RCL 13		
191	XEQ 01		
192	STO 05		$\sinh(R_{13}) \to R_{05}$
193	RCL 06		
194	/		
195	RCL 03		
196	*		
197	RCL 11		
198	+		
199	2		
200	/		
201	STO 04		$L' \to R_{04}$
202	RCL 11		
203	-		
204	ABS		
205	1		
206	X>Y?		
207	GTO 25		
208	RCL 04		
209	GTO "ITERAT"		
210	♦LBL 25		
211	RCL 01		
212	RCL 04		
213	/		
214	STO 09		$kd \to R_{09}$
*215	"KD="		$kd \to R_x$
*216	PRA		
*217	PRX		
218	RTN		
219	♦LBL 01		subroutine sinh( ) lines 219-228
220	STO 07		
221	E↑X		
222	RCL 07		
223	CHS		

* DELETE THESE LINES IF A PRINTER IS NOT AVAILABLE. 101R-41CV-5

ALSO SEE 'OPERATING LIMITS AND WARNINGS' ON PAGE 101R-41CV-1.

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
224	E↑X		
225	-		
226	2		
227	/		
228	RTN		
229	♦LBL 02		subroutine cosh( ) lines 229-238
230	STO 07		
231	E↑X		
232	RCL 07		
233	CHS		
234	E↑X		
235	+		
236	2		
237	/		
238	"END"		
239	.END.		

STEP	KEY ENTRY	KEY CODE	COMMENTS

* DELETE THESE LINES IF A PRINTER IS NOT AVAILABLE. 101R-41CV-6
ALSO SEE 'OPERATING LIMITS AND WARNINGS' ON PAGE 101R-41CV-1.

Program Description

Program Title	102R-41CV Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle (RPN Logic)		
Name	T.L. Walton, Jr.	Date	1/82
Address	Coastal Engineering Research Center Kingman Building		
City	Fort Belvoir,	State Virginia	Zip Code 22060

Program Description, Equations, Variables, etc.

This program calculates breaking wave height, H_b, and breaking wave angle, α_b, using linear wave theory approximations combined with the shallow-water breaking assumption. Input parameters are wave height, H, wave period, T, wave angle, α, and the water depth, d, where the preceding three variables are measured. An additional input parameter is nearshore beach slope, m. The ratio of the breaking wave height to the water depth at breaking is predicted using the equation

$$\kappa = H_b/d_b = 1.16\left(\frac{m}{\sqrt{H_o'/L_o}}\right)^{0.22}$$

from Singamsetti and Wind (1980), where d_b is the water depth at breaking, H_o' the deepwater wave height, and L_o the deepwater wavelength. This solution requires the assumption of straight and parallel offshore bottom contours for the application of Snell's law of refraction. Input wave parameters H, T, and α can be in any depth of water, d. Algorithm uses English or metric system of units. The development of the equation is derived on the attached solution sheet.

REFERENCES

SINGAMSETTI, S.R., and WIND, H.G., "Characteristics of Shoaling and Breaking Periodic Waves Normally Incident to Plane Beaches of Constant Slope," Report No. M1371, Toegepast Onberzoek Waterstaat, July 1980.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

102R-41CV-1

Development of the equation:

From conservations of energy

$$\frac{\gamma H^2}{8} C_g \cos \alpha = \frac{\gamma H_i{}^2}{8} C_{gi} \cos \alpha_i \tag{1}$$

where the subscript i indicates incident wave parameters.

If left-hand side of above equation represents conditions at breaking then

$$C_g = C = C_b = \sqrt{g d_b} = \sqrt{g H_b / \kappa} \tag{2}$$

where

$$\kappa = \frac{H_b}{d_b} \tag{3}$$

Now assume

$$\kappa = 1.16 \left(\frac{m}{\sqrt{H_o'/L_o}} \right)^{0.22} \tag{4}$$

where H_o' is unrefracted deepwater wave height.

Using (1), (2), (3), and (4) it can be found

$$H_b = \left\{ \left(\frac{\kappa}{g} \right)^{1/2} H_i{}^2 \, C_{gi} \cos \alpha_i \right\}^{2/5} \tag{5}$$

From Snell's law of refraction

$$\frac{\sin \alpha_b}{C_b} = \frac{\sin \alpha_i}{C_i} \tag{6}$$

therefore,

$$\sin \alpha_b = \left(\frac{\sin \alpha_i}{C_i} \right) \left\{ \left(\frac{g}{\kappa} H_b \right)^{1/2} \right\} \tag{7}$$

User Instructions

102R-41CV LINEAR APPROXIMATION TO BREAKING WAVE HEIGHT AND BREAKING WAVE ANGLE (RPN LOGIC)

SIZE: 021

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	LOAD PROGRAM (ANGLE B)		[XEQ] "ANGLEB"	E OR M?
	TO CALCULATE H_b, α_b IN ENGLISH UNITS:			
2	PRESS GTO "E"		GTO "E"	
3	PRESS R/S		[R/S]	SLOPE?
4	ENTER SLOPE m, PRESS R/S	m	[R/S]	DEPTH?
5	ENTER DEPTH D, PRESS R/S	d (ft.)	[R/S]	ANGLE?
6	ENTER ANGLE α, PRESS R/S	α (deg.)	[R/S]	H?
7	ENTER WAVE HEIGHT, H, PRESS R/S	H (ft.)	[R/S]	PERIOD?
8	ENTER WAVE PERIOD T, PRESS R/S	T (sec)	[R/S]	
9	READ kd			kd
10	PRESS R/S, READ n		[R/S]	n
11	PRESS R/S, READ C_g		[R/S]	C_g (ft/sec)
12	PRESS R/S, READ K_s		[R/S]	K_s
13	PRESS R/S, READ $H_o' = H_o K_r$		[R/S]	H_o' (ft.)
14	PRESS R/S, READ H_b		[R/S]	H_b (ft.)
15	PRESS R/S, READ α_b		[R/S]	α_b (deg.)
	TO CALCULATE H_b, α_b IN METRIC UNITS:			
	FOLLOW THE SAME INSTRUCTIONS AS ABOVE EXCEPT:			
	PRESS GTO "M" AT STEP 2a.			
	IMPUT D and H IN METERS.			
	C_g, H_o', H_b ARE OUTPUT IN	M/s, m,	m RESPECTIVELY.	
	note: " = [ALPHA]			

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User Instructions

SIZE:

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
	EXAMPLE:			
	Imput $m = 0.10$, $d = 50ft$ $(15.24m)$			
	$\alpha = 30°$, $H = 18ft$ $(5.4878m)$			
	$T = 8 sec.$			
	ENGLISH PRINTOUT: METRIC PRINTOUT:			

```
ENGLISH                          METRIC
SLOPE=                           SLOPE=
        0.1000  ***                      0.1000  ***
DEPTH=                           DEPTH=
       50.0000  ***                     15.2439  ***
ANGLE=                           ANGLE=
       30.0000  ***                     30.0000  ***
H=                               H=
       18.0000  ***                      5.4878  ***
PERIOD=                          PERIOD=
        8.0000  ***                      8.0000  ***
KD=                              KD=
        1.1631  ***                      1.1600  ***
N=                               N=
        0.7294  ***                      0.7302  ***
CG=                              CG=
       24.6248  ***                      7.5367  ***
KS=                              KS=
        0.9124  ***                      0.9103  ***
HOKR=                            HOKR=
       19.7284  ***                      6.0286  ***
HB=                              HB=
       16.9807  ***                      5.1855  ***
AB=                              AB=
       20.7859  ***                     20.7406  ***
```

102R-41CV-4

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
01	♦LBL "ANGLEB"		
02	"E OR M ?"		
03	PROMPT		
04	♦LBL E		
05	32.2		
06	STO 14		
*07	"ENGLISH"		$g(\text{English}) \to R_{14}$
*08	PRA		
09	GTO 01		
10	♦LBL "M"		
*11	"METRIC"		
*12	PRA		
13	9.81		
14	STO 14		$g(\text{Metric}) \to R_{14}$
15	♦LBL 01		
*16	"SLOPE="		
*17	PRA		
18	"SLOPE?"		
19	PROMPT		
*20	PRX		
21	STO 15		$m \to R_{15}$
*22	"DEPTH="		
*23	PRA		
24	"DEPTH?"		
25	PROMPT		
*26	PRX		
27	STO 01		$d \to R_{01}$
28	PI		
29	*		
30	2		
31	*		
32	STO 12		$2\pi d \to R_{12}$
*33	"ANGLE="		
*34	PRA		
35	"ANGLE?"		
36	PROMPT		
*37	PRX		
38	STO 00		
*39	"H="		
*40	PRA		
41	"H?"		
42	PROMPT		
*43	PRX		
44	STO 08		$H \to R_{08}$
*45	"PERIOD="		
*46	PRA		
47	"PERIOD?"		
48	PROMPT		
*49	PRX		
50	STO 02		$T \to R_{02}$
51	X↑2		
52	RCL 14		
53	*		
54	2		
55	/		
56	PI		
57	/		
58	STO 03		$L_o \to R_{03}$
59	♦LBL "ITERAT"		
60	STO 11		$L_{old} \to R_{11}$
61	1/X		
62	RCL 12		
63	*		
64	STO 13		$\frac{2\pi d}{L_{old}} \to R_{13}$
65	XEQ 02		
66	STO 06		$\cosh(R_{13}) \to R_{06}$
67	RCL 13		
68	XEQ 03		
69	STO 05		$\sinh(R_{13}) \to R_{05}$
70	RCL 06		
71	/		
72	RCL 03		
73	*		
74	RCL 11		
75	+		
76	2		
77	/		
78	STO 04		
79	RCL 11		
80	-		
81	ABS		
82	1		
83	X>Y?		
84	GTO 13		
85	RCL 04		
86	GTO "ITERAT"		
87	♦LBL 13		
88	RCL 12		
89	RCL 04		
90	/		
91	STO 09		$kd \to R_{09}$
*92	"KD="		→ display
*93	PRA		
*94	PRX		
95	STOP		
96	2		
97	*		
98	STO 11		$2kd \to R_{11}$
99	XEQ 03		
100	1/X		
101	RCL 11		
102	*		
103	1		
104	+		
105	2		
106	/		
107	STO 01		$n \to R_{01}$
*108	"N="		→ display
*109	PRA		
*110	PRX		
111	STOP		
112	RCL 04		

*DELETE THESE STEPS IF A PRINTER IS NOT AVAILABLE. 102R-41CV-5

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	*		
114	RCL 02		
115	/		
116	STO 04		$C_g \rightarrow R_{04}$
*117	"CG="		$\rightarrow$ display
*118	PRA		
*119	PRX		
120	STOP		
121	1/X		
122	RCL 02		
123	*		
124	RCL 14		
125	*		
126	4		
127	/		
128	PI		
129	/		
130	SQRT		
131	STO 11		$K_s \rightarrow R_{11}$
*132	"KS="		$\rightarrow$ display
*133	PRA		
*134	PRX		
135	STOP		
136	RCL 03		
137	RCL 11		
138	/		H_o' in display
*139	"HOKR="		
*140	PRA		
*141	PRX		
142	STOP		
143	RCL 03		
144	/		
145	SQRT		
146	RCL 15		
147	/		
148	1/X		
149	.22		
150	Y↑X		
151	1.16		
152	*		
153	RCL 14		
154	/		
155	STO 06		
156	RCL 08		
157	X↑2		
158	RCL 04		
159	*		
160	RCL 00		
161	COS		
162	*		
163	.4		
164	Y↑X		
165	RCL 06		
166	.2		
167	Y↑X		
168	*		
*169	"HB="		H_b in display
*170	PRA		
*171	PRX		
172	STOP		
173	RCL 06		
174	1/X		
175	*		
176	SQRT		
177	RCL 00		
178	SIN		
179	*		
180	RCL 04		
181	/		
182	RCL 01		
183	*		
184	ASIN		
*185	"AB="		α_b in display
*186	PRA		
*187	PRX		
188	STOP		
189	RTN		
190	♦LBL 03		sinh( ) subroutine
191	STO 07		
192	E↑X		
193	RCL 07		
194	CHS		
195	E↑X		
196	-		
197	2		
198	/		
199	RTN		
200	♦LBL 02		cosh( ) subroutine
201	STO 07		
202	E↑X		
203	RCL 07		
204	CHS		
205	E↑X		
206	+		
207	2		
208	/		
209	.END.		

* DELETE THESE STEPS IF A PRINTER IS NOT AVAILABLE.

Program Description

Program Title	103R-41C Shallow-Water Wave Forecasting Equations (RPN Logic)
Name	T.L. Walton, Jr. — Date 1/82
Address	Coastal Engineering Research Center, Kingman Building
City	Fort Belvoir, — State Virginia — Zip Code 22060

Program Description, Equations, Variables, etc.

This algorithm computes the wave height, H, wave period, T, and minimum duration, t, from input values of the water depth, d, fetch length, F, and adjusted windspeed, U_A, using equations (1), (2), and (3) of CETN-I-6. Equations (1) and (2) are for constant water depth and unlimited wind duration and have been revised from equations (3-25) and (3-26) of the Shore Protection Manual. Wave height and period in this algorithm are significant wave height and period. Algorithm uses English or metric system of units.

REFERENCES

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Method for Determining Adjusted Windspeed, U_A, for Wave Forecasting," CETN-I-5, Fort Belvoir, Va., 1981.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Shallow Water," CETN-I-6, Fort Belvoir, Va., 1981.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Deep Water," CETN-I-7, Fort Belvoir, Va., 1981.

Operating Limits and Warnings

If a printer is not used, R/S must be inserted where output values are desired (i.e., where printer output steps are deleted).

103R-41CV-1

User Instructions

103R-41CV SHALLOW WATER WAVE FORECASTING EQUATIONS (RPN LOGIC) SIZE: 021

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	LOAD PROGRAM (FOCAST)		[XEQ] FOCAST	E OR M?
	TO CALCULATE IN ENGLISH UNITS:			
2	PRESS GTO "E"		GTO "E"	
3	PRESS R/S.		[R/S]	UA?
4	ENTER U_A, PRESS R/S	U_A(mph)	[R/S]	FETCH?
5	ENTER FETCH F, PRESS R/S	F(miles)	[R/S]	DEPTH?
6	ENTER DEPTH D, PRESS R/S	d (ft)	[R/S]	
7	READ H (wave height)			H(ft.)
8	READ T (wave period)			T(sec)
9	READ TIME IN HOURS. (minimum duration)			t(hours)
	TO CALCULATE IN METRIC UNITS:			
2a	PRESS GTO "M"			
3a-9a	SAME AS STEPS 3-9 ABOVE EXCEPT			
	INPUT U_A (kilometers/hr.) and			
	F (kilometers) and			
	d (meters)			
	OUTPUT H (meters)			
	note: " = [ALPHA]			103R-41CV-2

103R-41CV-2

User Instructions

STEP	INSTRUCTIONS	INPUT	FUNCTION	SIZE: DISPLAY
	EXAMPLES 1 and 1a			
	1. ENGLISH UNITS, USING			
	U_A = 40 mph, F = 300 miles			
	d = 20 ft.			
	1a. METRIC UNITS, USING			
	U_A = 64.416 km/hr, F = 483.12 km			
	d = 6.1 m			
	PRINTOUTS			
	ENGLISH UNITS: METRIC UNITS:			

ENGLISH UNITS:

```
ENGLISH
UA=
          40.0000    ***
FETCH=
         300.0000    ***
DEPTH=
          20.0000    ***
H=
          4.5313 ft. ***
T=
          5.6033 sec.***
TIME=
          3.7253 hrs.***
```

METRIC UNITS:

```
METRIC
UA=
          64.4160    ***
FETCH=
         483.1200    ***
DEPTH=
           6.1000    ***
H=
          1.3809 m.  ***
T=
          5.6032 sec.***
TIME=
          3.7307 hrs.***
```

103R-41CV-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
01	♦LBL "FOCAST"		
02	"E OR M ?"		
03	PROMPT		
04	♦LBL E		
05	32.2		
06	STO 09		g(English) $\to R_{09}$
07	1.47		
08	STO 07		English Conversion $\to R_{07}$
09	5280		
10	STO 01		English Conversion $\to R_{01}$
*11	"ENGLISH"		
*12	PRA		
13	GTO 01		
14	♦LBL "M"		
*15	"METRIC"		
*16	PRA		
17	9.81		
18	STO 09		g(Metric) $\to R_{09}$
19	.2778		
20	STO 07		metric conversion $\to R_{07}$
21	1000		
22	STO 01		Metric Conversion $\to R_{01}$
23	♦LBL 01		
24	"UA?"		
25	PROMPT		
*26	"UA="		
*27	PRA		
*28	PRX		
29	STO 03		$U_A \to R_{03}$
30	"FETCH?"		
31	PROMPT		
*32	"FETCH="		
*33	PRA		
*34	PRX		
35	STO 05		$F \to R_{05}$
36	"DEPTH?"		
37	PROMPT		
*38	"DEPTH="		
*39	PRA		
*40	PRX		
41	STO 06		$d \to R_{06}$
42	RCL 03		
43	RCL 07		
44	*		
45	STO 07		converted $U_A \to R_{07}$
46	RCL 09		
47	RCL 07		
48	X↑2		
49	/		
50	STO 08		$g/U_A^2 \to R_{08}$
51	RCL 06		
52	*		
53	STO 00		$gd/U_A^2 \to R_{00}$
54	RCL 08		
55	RCL 01		
56	*		
57	RCL 05		
58	*		
59	STO 01		$gF/U_A^2 \to R_{01}$
60	RCL 00		
61	.75		
62	Y↑X		
63	.53		
64	*		
65	XEQ 03		
66	STO 04		$\tanh\left[.53\left(\frac{gd}{U_A^2}\right)^{0.75}\right] \to R_{04}$
67	RCL 01		
68	SQRT		
69	.00565		
70	*		
71	RCL 04		
72	/		
73	XEQ 03		$\tanh\left[\frac{.00565}{R_{04}}\left(\frac{gF}{U_A^2}\right)^{0.5}\right]$
74	RCL 04		
75	*		
76	.283		
77	*		
78	RCL 08		
79	/		
*80	"H="		
*81	PRA		
*82	PRX		
83	RCL 00		
84	.375		
85	Y↑X		
86	.833		
87	*		
88	XEQ 03		$\tanh\left[0.833\left(\frac{gd}{U_A^2}\right)^{0.375}\right]$
89	STO 04		$\to R_{04}$
90	RCL 01		
91	.333		
92	Y↑X		
93	.0379		
94	*		
95	RCL 04		
96	/		
97	XEQ 03		$\tanh\left[\frac{0.0379}{R_{04}}\left(\frac{gF}{U_A^2}\right)^{0.333}\right]$
98	RCL 04		
99	*		
100	7.54		
101	*		
102	RCL 08		
103	/		
104	RCL 07		
105	/		
*106	"T="		
*107	PRA		
*108	PRX		
109	RCL 09		
110	*		
111	RCL 07		
112	/		

103R-41CV-4

* DELETE IF PRINTER IS NOT AVAILABLE
ALSO SEE 'operating Limits and Warnings' on p. 103R-41CV-1

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS

```
    113 2.333
    114 Y↑X
    115 537
    116 *
    117 RCL 07
    118 *
    119 RCL 09
    120 /
    121 3600
    122 /
   *123 "TIME="
   *124 PRA
   *125 PRX
    126 RTN
    127♦LBL 03
    128 STO 02
    129 E↑X
    130 RCL 02
    131 CHS
    132 E↑X
    133 -
    134 RCL 02
    135 E↑X
    136 RCL 02
    137 CHS
    138 E↑X
    139 +
    140 /
    141 .END.
```

103R-41CV-5

* DELETE IF PRINTER IS NOT AVAILABLE.
ALSO SEE 'Operating Limits and Warnings' ON P. 103R-41CV-1.

Program Description

Program Title	104R-41CV Depth-Limited Design Breaking Wave Height at Structure (RPN Logic)		
Name	T.L. Walton, Jr.	**Date**	1/82
Address	Coastal Engineering Research Center Kingman Building		
City	Fort Belvoir,	**State** Virginia	**Zip Code** 22060

Program Description, Equations, Variables, etc.

This algorithm computes the depth-limited breaking wave height at a structure for design purposes. It can be used in lieu of Figure 7-4 of the Shore Protection Manual. The equation for the curves in Figure 7-4 is not given in the SPM but can be found by simultaneous solution of SPM equations (2-91), (2-92), (2-93), (7-3), and (7-4). Input is wave period, T, and water depth at the structure toe, d_s. The development of the equation is derived on the attached solution sheet. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I and II, Chs, 2 and 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

104R-41CV-1

The following equations are given in the Shore Protection Manual:

$$\frac{d_b}{H_b} = \frac{1}{b - (aH_b/gT^2)} \tag{2-91}$$

$$a = 43.75(1 - e^{-19m}) \tag{2-92}$$

$$b = \frac{1.56}{(1 + e^{-19.5m})} \tag{2-93}$$

$$x_p = \tau_p H_b = (4.0 - 9.25\ m)H_b \tag{7-3}$$

$$H_b = \frac{d_s}{\beta - m\tau_p} \tag{7-4}$$

Equation (7-4) can be rewritten in dimensionless form as:

$$\hat{H}_b = \frac{\hat{d}_s}{\left[(b - a\hat{H}_b)^{-1} - m\tau_p\right]}$$

where

$$\hat{H}_b = H_b/gT^2 \text{ and } \hat{d}_s = d_s/gT^2$$

The above equation can then be solved via the quadratic formula for $\hat{H}_b$ in terms of $\hat{d}_s$, τ_p, m, a, and b where the positive root provides useful results.

$$\hat{H}_b = \left\{(m\tau_p b - a\hat{d}_s - 1) + \left[(m\tau_p b - a\hat{d}_s - 1)^2 + 4am\tau_p\ b\hat{d}_s\right]^{1/2}\right\} . (2am\tau_p)^{-1}$$

This is the equation used in the program for design breaking wave height.

104R-41CV-2

User Instructions

104R-41CV DEPTH-LIMITED DESIGN BREAKING WAVE HEIGHT AT STRUCTURE (RPN LOGIC)

SIZE: 021

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	LOAD PROGRAM (HB)		[XEQ] "HB"	E OR M?
	TO CALCULATE H_b IN ENGLISH UNITS:			
2	PRESS GTO "E"		GTO "E"	
3	PRESS R/S		[R/S]	SLOPE?
4	ENTER SLOPE m, PRESS R/S	m	[R/S]	DEPTH?
5	ENTER DEPTH D, PRESS R/S	d(ft)	[R/S]	PERIOD?
6	ENTER PERIOD T, PRESS R/S	T(sec)	[R/S]	
7	READ H_b IN FEET			H_b (ft)
	TO CALCULATE H_b IN METRIC UNITS:			
2a	PRESS GTO "M"		GTO "M"	
3a	PRESS R/S		[R/S]	SLOPE?
4a	ENTER SLOPE m, PRESS R/S	m	[R/S]	DEPTH?
5a	ENTER DEPTH D, PRESS R/S	d(meters)	[R/S]	PERIOD?
6a	ENTER PERIOD T, PRESS R/S	T(sec)	[R/S]	
7a	READ H_b IN METERS			H_b(meters)
	Example 1 and 1a			
	m = 0.10 , d = 10ft (3.05m), T = 10sec			
	ENGLISH PRINTOUT: METRIC PRINTOUT:			

```
ENGLISH
SLOPE=
          0.1000    ***
DEPTH=
         10.0000    ***
PERIOD=
         10.0000    ***
HB=
         17.9812    ***
```

```
METRIC
SLOPE=
          0.1000    ***
DEPTH=
          3.0500    ***
PERIOD=
         10.0000    ***
HB=
          5.4631    ***
```

note: " = [ALPHA]

104R-41CV-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
01	◆LBL "HB"		
02	"E OR M ?"		
03	PROMPT		
04	◆LBL E		
05	32.2		
06	STO 08		$g(\text{English}) \rightarrow R_{08}$
* 07	"ENGLISH"		
* 08	PRA		
09	GTO 01		
10	◆LBL "M"		
* 11	"METRIC"		
* 12	PRA		
13	9.81		
14	STO 08		$g(\text{Metric}) \rightarrow R_{08}$
15	◆LBL 01		
* 16	"SLOPE="		
* 17	PRA		
18	"SLOPE?"		
19	PROMPT		
* 20	PRX		
21	STO 00		$m \rightarrow R_{00}$
* 22	"DEPTH="		
* 23	PRA		
24	"DEPTH?"		
25	PROMPT		
* 26	PRX		
27	STO 07		$d_s \rightarrow R_{07}$
* 28	"PERIOD="		
* 29	PRA		
30	"PERIOD?"		
31	PROMPT		
* 32	PRX		
33	STO 09		$T \rightarrow R_{09}$
34	X↑2		
35	RCL 08		
36	*		
37	1/X		
38	RCL 07		
39	*		
40	STO 01		$\frac{d_s}{gT^2} \rightarrow R_{01}$
41	RCL 00		
42	19		
43	*		
44	CHS		
45	E↑X		
46	CHS		
47	1		
48	+		
49	43.75		
50	*		
51	STO 03		$43.75(1-e^{-19m}) \rightarrow R_{03}$
52	RCL 00		
53	19.5		
54	*		
55	CHS		
56	E↑X		
57	1		
58	+		
59	1.56		
60	/		
61	1/X		
62	STO 04		
63	RCL 00		
64	ENTER↑		
65	9.25		
66	*		
67	4		
68	-		
69	CHS		
70	RCL 00		
71	*		
72	STO 05		$mJ_p = m(4-9.25m) \rightarrow R_{05}$
73	RCL 04		
74	*		
75	1		
76	-		
77	RCL 01		
78	RCL 03		
79	*		
80	-		
81	STO 06		$mJ_p b - a\hat{d}_s - 1 \rightarrow R_{06}$
82	X↑2		
83	4		
84	RCL 03		
85	*		
86	RCL 04		
87	*		
88	RCL 05		
89	*		
90	RCL 01		
91	*		
92	+		
93	SQRT		
94	RCL 06		
95	+		
96	2		
97	/		
98	RCL 03		
99	/		
100	RCL 05		
101	/		
102	RCL 01		
103	/		
104	RCL 07		
105	*		
* 106	"HB="		H_b in display
* 107	PRA		
* 108	PRX		
109	STOP		
110	.END.		

* THESE STEPS MUST BE DELETED IF NO PRINTER IS AVAILABLE

101R-41CV-4

Program Description

Program Title	105R-41CV Wave Transmission - Fuchs' Equation (RPN Logic)
Name	T.L. Walton, Jr. — **Date** 1/82
Address	Coastal Engineering Research Center, Kingman Building
City	Fort Belvoir, — **State** Virginia — **Zip Code** 22060

Program Description, Equations, Variables, etc.

This algorithm computes wavelength, L, in water depth, d, given the wave period, T. The program then computes wave transmission over a thin vertical barrier in water depth, d, using Fuchs' equation:

$$\frac{H_t}{H_i} = \sqrt{1 - \frac{\frac{4\pi h}{L} + \sinh \frac{4\pi h}{L}}{\frac{4\pi d}{L} + \sinh \frac{4\pi d}{L}}}$$

where H_t is the transmitted wave height, H_i the incident wave height, and h the height of barrier. Note that this equation *cannot* be used when wave transmission is by overtopping of a structure. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. II, Ch. 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, p. 7-62.

Operating Limits and Warnings

User Instructions

105R-41CV WAVE TRANSMISSION - FUCHS' EQUATION (RPN logic)

SIZE: 021

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	LOAD PROGRAM (FUCH)		[XEQ] "FUCH"	
	TO CALCULATE IN ENGLISH UNITS:			
2	PRESS GTO "E"		GTO "E"	
3	PRESS R/S		[R/S]	DEPTH?
4	ENTER DEPTH D, PRESS R/S	d (ft.)	[R/S]	SIL HT?
5	ENTER SILL HEIGHT H, PRESS R/S	h(ft)	[R/S]	PERIOD?
6	ENTER PERIOD T, PRESS R/S	T(sec)	[R/S]	
7	READ $K_t = H_T/H_i$ (TRANSMISSION			K_t
	COEFFICIENT)			
	TO CALCULATE IN METRIC UNITS:			
2a	PRESS GTO "M"		GTO "M"	
	STEPS 3a-7a ARE THE SAME AS STEPS 3-7 ABOVE EXCEPT			
	IMPUT d, h, IN METERS			
	OUTPUT L (PRINTER ONLY) METERS			
	Example 1 and 1a:			
	Values used: d = 15ft (4.5732m), h = 10ft (3.0488m), T = 10sec			
	PRINTOUTS:			
	note: " = [ALPHA]			

Printouts:

```
ENGLISH                      METRIC
DEPTH=                       DEPTH=
       15.0000 ***                  4.5732 ***
SIL HT=                      SIL HT=
       10.0000 ***                  3.0488 ***
PERIOD=                      PERIOD=
       10.0000 ***                 10.0000 ***
L=                           L=
      213.0238 ***                 64.9450 ***
KT=                          KT=
        0.5977 ***                  0.5977 ***
```

105R-41CV-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
01	♦LBL "FUCH"		
02	"E OR M ?"		
03	PROMPT		
04	♦LBL E		
05	32.2		
06	STO 06		g(English) $\rightarrow R_{06}$
* 07	"ENGLISH"		
* 08	PRA		
09	GTO 01		
10	♦LBL "M"		
* 11	"METRIC"		
* 12	PRA		
13	9.81		
14	STO 06		g(Metric) $\rightarrow R_{06}$
15	♦LBL 01		
16	"DEPTH?"		
17	PROMPT		
* 18	"DEPTH="		
* 19	PRA		
* 20	PRX		
21	2		
22	*		
23	PI		
24	*		
25	STO 00		$2\pi d \rightarrow R_{00}$
26	"SIL HT?"		
27	PROMPT		
* 28	"SIL HT="		
* 29	PRA		
* 30	PRX		
31	STO 08		$h \rightarrow R_{08}$
32	"PERIOD?"		
33	PROMPT		
* 34	"PERIOD="		
* 35	PRA		
* 36	PRX		
37	X↑2		
38	RCL 06		
39	*		
40	2		
41	/		
42	PI		
43	/		
44	STO 01		$L_o \rightarrow R_{01}$
45	♦LBL "ITERAT"		
46	STO 03		$L_{old} \rightarrow R_{03}$
47	1/X		
48	RCL 00		
49	*		
50	STO 04		$\frac{2\pi d}{L_{old}} \rightarrow R_{04}$
51	E↑X		
52	RCL 04		
53	CHS		
54	E↑X		
55	-		
56	RCL 04		
57	E↑X		
58	RCL 04		
59	CHS		
60	E↑X		
61	+		
62	/		
63	RCL 01		$\tanh\left(\frac{2\pi d}{L_{old}}\right)$
64	*		
65	RCL 03		
66	+		
67	2		
68	/		
69	STO 02		$L' \rightarrow R_{02}$
70	RCL 03		
71	-		
72	ABS		
73	1		
74	X>Y?		
75	GTO 13		
76	RCL 02		
77	GTO "ITERAT"		
78	♦LBL 13		
79	RCL 02		
* 80	"L="		
* 81	PRA		
* 82	PRX		
83	1/X		
84	RCL 00		
85	*		
86	2		
87	*		
88	STO 06		$4\pi d/L \rightarrow R_{06}$
89	XEQ 03		
90	RCL 06		
91	+		
92	STO 07		$R_{06} + \sinh(R_{06}) \rightarrow R_{07}$
93	4		
94	ENTER↑		
95	PI		
96	*		
97	RCL 08		
98	*		
99	RCL 02		
100	/		
101	STO 09		$\frac{4\pi h}{L} \rightarrow R_{09}$
102	XEQ 03		
103	RCL 09		
104	+		
105	RCL 07		
106	/		
107	CHS		
108	1		
109	+		$H_t/H_i = K_t$ in display
110	SQRT		
* 111	"KT="		
* 112	PRA		
* 113	PRX		

* THESE LINES MUST BE DELETED IF A PRINTER IS NOT AVAILABLE.

105R-41CV-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS

```
114 RTN
115+LBL 03
116 STO 05
117 E↑X
118 RCL 05
119 CHS
120 E↑X
121 -
122 2
123 /
124 .END.
```

105R-41CV-4

* THESE LINES MUST BE DELETED IF A PRINTER IS NOT AVAILABLE.

APPENDIX

BLANK PROGRAM FORMS

Program Description

Program Title		
Name		**Date**
Address		
City	State	Zip Code

Program Description, Equations, Variables, etc.

Operating Limits and Warnings

User Instructions

Program Title

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001							
				060			
010							
				070			
020							
				080			
030							
				090			
040							
				100			
050							
				110			

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
				170			
120							
				180			
130							
				190			
140							
				200			
150							
				210			
160							
				220			

Walton, Todd L.
Hand-held calculator algorithms for coastal engineering (second series) / by Todd L. Walton, Jr.--Fort Belvoir, Va. : U.S. Army, Corps of Engineers, Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1982.
[41] p. : 27 cm.--(Coastal engineering technical aid ; no. 82-4)
Cover title.
"November 1982."
This report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included for use with HP41CV hand-held calculators which employ the Reverse Polish Notation (RPN). These programs can be used to compute linear wave parameters, orbital velocities, breaking wave height and direction, shallow-water wave forecasts, depth-limited breaking wave height, and wave transmission past a vertical barrier.
1. Calculator algorithms. 2. Coastal engineering. 3. Wave generation. 4. Wave transformation. I. Title. II. Series.
TC203 .U581ta no. 82-4 627

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Hand-held calculator algorithms for coastal engineering (second series) / by Todd L. Walton, Jr.--Fort Belvoir, Va. : U.S. Army, Corps of Engineers, Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1982.
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